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A DATABASE OF PROBLEM BUILDINGS: LEARNING BY PAST MISTAKES

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INTRODUCTION

An implicit objective of the designers of modern office buildings is the creation of a "healthy" work environment, one in which building occupants are satisfied with indoor environmental conditions. However, since the 1970's, it has become apparent that occupants of many buildings are not satisfied, frequently reporting a high prevalence of health and comfort complaints which they relate to their work environment. This dissatisfaction has adversely effected productivity through higher absenteeism and increased stress. This type of problem is commonly referred to as the "Sick Building Syndrome". This syndrome was first recognized in Scandinavia in the early 1970's, and has subsequently been widely studied in other countries of Western Europe and in North America (1,2). The most commonly reported symptoms include eye, nose and throat irritation, headache, fatigue, nausea, dizziness and skin rash or itchiness. In addition, occupants of sick buildings often report comfort problems such as a lack of fresh air, stuffiness, inadequate temperature control and unpleasant odours.

A large number of investigations of sick buildings have now been conducted by government and private sector organizations. These past building investigations offer design professionals a vast quantity of valuable information about "mistakes" made in the past. Designers can learn how to create "healthy buildings" in the future from the mistakes that have caused "sick buildings" in the past.

A DATABASE OF PROBLEM BUILDINGS

An information system, the Building Performance Database (BPD) has been developed as a tool for building professionals and researchers. The BPD currently contains the results of 366

building investigations conducted by both government agencies (such as NIOSH and Health and Welfare Canada) and private sector organizations. The BPD is an on-line synthesis of a wide range of information collected by the investigators of sick buildings. The database includes bibliographic information about the investigators and their conclusions, architectural and engineering data, and the results of air quality measurements, building system testing and surveys of occupant health and comfort.

BPD is installed on a mainframe computing system in Canada which can be accessed worldwide through existing communications networks. A more complete description of the analytical capabilities of the BPD has been presented elsewhere (3).

PAST "MISTAKES"

The findings from past investigations can provide useful information to design professionals as they plan future buildings. Knowledge about the causes of past occupant complaints can influence design decisions.

Table One summarizes the conclusions from the 366 reports currently contained in the BPD. Review of the data in BPD shows that in many cases, investigators may identify several factors which they feel had all contributed to the building related problems. Consequently, the table summarizes those factors which have been reported by investigators as contributing to building problems. These factors include ventilation related problems, specific indoor pollutants, stress and ergonomic design. Because investigators have frequently indentified more than one cause in a building, the total number of suspected causes in the table does not equal the number of reports in the BPD. This format differs from tables previously developed by NIOSH and Health and Welfare Canada (4,5,6), which have reported one cause per building (i.e. 400 investigations and 400 suspected causes), which may have oversimplified their results. As the objective of this paper is to provide designers with input into future design decisions, the table provides more detail on specific building problems than those of NIOSH and Health and Welfare Canada.

TABLE 1

INVESTIGATOR'S CONCLUSIONS FROM REPORTS CONTAINED IN THE BUILDING PERFORMANCE DATABASE

SUSPECTED CAUSE INDENTIFIED	Number	Percent
VENTILATION CONTROL PROBLEM	159	39.0%
- lack of outside air		
- poor air distribution		
- poor temperature control		
- operational deficiency		
VENTILATION INFILTRATION PROBLEM	40	10.0%
- reentry of exhaust fumes		
- outside infiltration		
INDOOR SOURCES		28.1%
- offgassing from building materials	27	
- printshops/duplicators	17	
- microbial	14	
- smoking	12	
- fibrous insulation	8	
- chemical storage	6	
- cleaning solvents	6	
- pesticides	5	
- lighting	5	
- refrigerant spill	4	
- carpet shampoo	4	
- other (boilers,water leaks, etc.)	7	
STRESS	12	2.9%
ERGONOMIC/WORKSTATION DESIGN	5	1.2%
UNDETERMINED CAUSE	42	10.2%
NO PROBLEM IN BUILDING	35	8.6%
TOTAL	408	100.0%

Ventilation Related Problems

"Ventilation Related" inadequacies are the most commonly reported cause of problems in buildings. A differentiation can be made between problems of "control" and "infiltration".

Ventilation Control Problems. In 39% of the cases contained in BPD, investigators found problems such as inadequate outside air supply, poor air distribution, poor temperature control, a lack of humidification, and various operational deficiencies (such as mechanical failure and poor maintenance practices). All of these causes are "control" problems within the mechanical systems, that

can often be corrected with fine tuning of the systems. Although not specifically stated in the report conclusions, ventilation control inadequacies probably contribute to other problems in buildings. For example, in those reports where a specific indoor pollutant was cited as the suspected cause, e.g. offgassing of formaldehyde or smoking, the specific pollutant may have been removed from the building if the mechanical systems had been operating effectively.

Ventilation Infiltration Problems. In 10% of the investigations, the cause of building problems was contamination of the outside air supply, resulting from inappropriate location of an outside air intake. Investigators have identified two distinct causes of infiltration problems. First, reentrainment of air exhausted from the building due to the close proximity of air intake and exhaust vents. Second, infiltration from external sources such as automobiles or industry due to improper location of outside air intakes, e.g. at street level on busy downtown streets, adjacent to loading zones or downwind from industrial plants. Designers of future buildings must make certain that outside air intakes are not located such that reentrainment or external infiltration can occur.

Indoor Sources

Specific sources of indoor pollution were cited as the suspected causes of problems in 28.1% of the reports contained in BPD. The specific sources are identified in the table. The most commonly reported sources include offgassing from various building furnishings and finishing materials (20 reports), contamination from print shops, spirit duplicators and blueprint machines (17 reports), and microbial contamination (14 reports). Microbial contamination may partly also be considered "ventilation related", as problems have occurred as a result of the presence of standing water and dampness in HVAC system components. Smoking has been cited as contributory factor to building problems in 12 reports contained in BPD. Other identified sources include pesticides, insulation materials, carpet shampoo and leakage from boilers and water piping.

Stress

In 12 investigations, stress was reported as a contributory factor to the building related problems. In these cases, investigators were unable to determine a physical cause. However,

negative occupant perceptions about the work environment was cited as the main problem. Investigators of problem buildings must take care not to intensify occupant concerns by their presence in the building and "speculation" about building problems prior to final analysis. Recent research has suggested that the presence of investigators in a building may act as a psychological stressor, intensifying occupant belief that problems exist (7). Such problems can be avoided with carefully designed and executed building evaluations. Standardized protocols for building evaluations have been developed by several researchers (8,9).

Ergonomic Design

An important consideration for interior designers is work station design. Although few investigators of sick buildings appear to have considered ergonomic factors, recent research has suggested that VDT work station design is an important factor in occupant comfort for many white collar workers (10). Poor work station design and/or interior layout wes cited as a suspected cause of building problems in five reports contained in BPD.

Unidentified Causes

In 42 cases, investigators were unable to determine the cause of building related problems. All environmental parameters were "normal", and mechanical systems were operating according to established standards.

No Problem in Building

In 35 cases, investigators concluded that there was no problem in the building under investigation, i.e. no health hazard existed. In most of these cases, investigators were asked to evaluate the potential for building related problems, rather than responding to specific complaints.

DISCUSSION

A vast array of information is now available to building design professionals and researchers, which identifies the probable reasons for occupant health and comfort complaints in modern office buildings. This information has been (and will continue to be) synthesized into a database information system, which may be accessed by building designers and engineers.

Review of the findings of the investigations contained in this

database suggest that some of the problems that have plagued many sick buildings could have been avoided at the design stage. This is not to say that designers should be blamed for all sick building problems. A building may have been appropriately designed, but later actions by the building users has created the problem. For example as a result of energy conservation measures, alteration or the building without attention to the mechanical systems, overcrowding, poor upkeep and maintenance, or introduction of specific sources of pollution to the building. Whatever the cause of past problems in sick buildings, tools such as the BPD will be valuable in the efforts to design healthier work environments in the future, in which occupants will be more satisfied with their indoor environment and consequently more productive.

One final word of caution. The creation of healthy buildings is not solely a design issue. Once a building has been properly designed, building operators and users should practice a preventative approach to ensure that the building stays healthy thoughout its life. The design stage should be viewed as the first stage of an ongoing process termed "Building Commissioning", which continues to monitor the functional performance of building through construction and occupancy (11,12).

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